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SPECIFICATION

Title of the Device:

LIQUID CRYSTAL COLOR DISPLAY DEVICE

Scope of Claim for Utility Model Registration

A liquid crystal color display device having a plurality of pixels and a switching element which corresponds to each of the plurality of pixels, and selectively supplies each of them with a video signal respectively, comprising: a bottom electrode which corresponds to the plurality of pixels and which is formed over a semiconductor provided with the switching element, a filter for selecting colors formed over the bottom electrode, and a liquid crystal formed over the filter, wherein the video signal is applied between a top electrode formed over a top surface of the liquid crystal and the bottom electrode.

Detailed Description of the Device

Industrial Field of the Device

The present invention relates to a device which displays color images using a liquid crystal flat display device.

Prior Art and Problem to be resolved by the Device

Conventionally, a mosaic color filter is attached to a surface of a liquid crystal as shown in FIG. 1 to display color images using a liquid crystal color display device. In FIG. 1, reference numeral (1) denotes a substrate made from silicon, amorphous silicon, or the like; (2), a liquid crystal; (3), a protective glass plate; and (4), a color filter. However, there arise problems as follows. In such a device, the color of unselected part of the filter can be seen, when external light falls as an allow indicates, and so the color reproducibility is bad. In addition, since the color filter (4) is formed to maintain a predetermined distance from the crystal liquid (2) by the protective glass plate (3), the color is subject to be mixed with the neighboring pixel when being looked from an angle. If masks of each pixel are formed to prevent the color from being mixed, the usability of light becomes deteriorated and bright color display can not be realized, also,

pixels become impossible to be smaller, and so high-resolution image can not be obtained.

Object of the Device

In view of the foregoing, it is an object of the present invention to realize high-quality color display with a simple structure.

Brief Description of the Device

The present invention is a liquid crystal color display device having a plurality of pixels and a switching element which corresponds to each of the plurality of pixels and selectively supplies each of them with a video signal respectively, comprising a bottom electrode which corresponds to the plurality of pixels and formed over a semiconductor provided with the switching element, a filter for selecting colors formed over the bottom electrode, and a liquid crystal formed over the filter, wherein the video signal is applied between a top electrode formed over the liquid crystal and the bottom electrode. According to the present invention, the device which displays high-quality color image with a simple structure can be realized.

Embodiment

FIG. 2 is a cross-sectional view for showing one part of a liquid crystal flat display device. Three liquid crystal cells (pixels) are shown in the FIG. 2.

In one of the liquid crystal cells, a p-type well (22) is formed over an n-type substrate (21). N regions (23) and (24) are formed over the p-type well (22). A SiO_2 layer (25) is formed over the p-type well (22) and each region (23), (24). Further, through-holes are formed in the SiO_2 layer (25) over the N region (23) and a conductive layer (26) constructing lines L_1 to L_m in Y-axis direction is formed. A conductive layer (27) which constructs a control electrode (gate) of switching elements M_{11} to M_{nm} is formed in the SiO_2 layer (25) between the N regions (23) and (24). A conductive layer (28) is formed over the p-type well (22) while partly overlapping the N region (24). Through-holes are formed in the SiO_2 layer (25) over the N region (24). A SiO_2 layer (29) is formed over those conductive layers (26) to (28). Further, through-holes are formed in the SiO_2 layer (29) over the conductive layer (28) to form a pixel electrode (bottom electrode) (30). A layer for cutting direct current (31) is formed over the pixel

electrode (30).

Over the layer for cutting direct current (31), color filters (32R), (32G), and (32B) are provided to each of the pixels, respectively. A layer for cutting direct current (33) is formed over the color filters (32R) to (32B). A liquid crystal (35) is provided over the layer for cutting direct current (33) via an alignment layer (34). And a target electrode (top electrode) (37) made of a transparent electrode, and a glass plate for protection (38) are formed over the liquid crystal (35) via an alignment layer (36).

In the device, when a signal is provided to the conductive layer (26), potential of the conductive layer (27) becomes high potential. Then, the signal provided to the conductive layer (26) is provided to the conductive layer (28) through the N regions (23) and (24), and then, stored by capacitance formed between the conductive layer (28) and the p-type well (22). The stored signal is provided to the pixel electrode (30) and a light transmittance of the liquid crystal (35) varies according to the potential difference between the picture electrode (30) and the target electrode (37).

For example, by using black color as a color pigment in the case of a GH type liquid crystal, the liquid crystal is changed its color to be from black to colorless according to the signal. Consequently, each pixel displays color by using a half-tone of black and the colors of the filters (32R) to (32B). A polarizer for photodetection (not shown) is provided between the glass plate (38) and the eyes of the observer.

FIG. 3 is a circuit diagram. Primary color signals of red (R), green (G), and blue (B) are respectively provided to input terminals (11R), (11G), and (11B). The input terminals are respectively connected through switching elements M_R, M_G, and M_B made of N channel FETs or the like. In addition, a 3-bit ring counter (12) is provided and pixel clock signals Φ_{1H} and Φ_{2H} to be described are provided to the counter (12) and a pulse signal for 3-bit are taken from the counter (11). The signal of each bit is provided to each control terminal of the switching elements M_R, M_G, and M_B to make each element turn ON sequentially and repeatedly. Therefore, a signal made of three primary color signals dot-sequentially mixed is outputted from the connection point of the output side of each terminal.

The signal is provided to lines L_1, L_2...L_m which are equivalent to the conductive

layer (26) in vertical (Y-axis) direction through switching elements M_1, $M_2 \ldots M_m$ made of N channel FET or the like. The term used herein "m" refers to the number of pixels in horizontal (X-axis) direction. Further, an m-stage shift register (13) is provided and m times as much pixel clock signals Φ_{1H} and Φ_{2H} as the horizontal frequency are provided to the shift register (13). Driving pulse signals ϕ_{H1}, $\phi_{H2} \ldots \phi_{Hm}$ which are progressively scanned by the clock signals Φ_{1H} and Φ_{2H} from each of the output terminals of the shift register (13) are provided to control terminals of the switching elements M_1 to M_m.

Each of one ends (N region (23)) of switching elements M_{11}, $M_{22} \ldots M_{n1}$; M_{12}, $M_{22} \ldots M_{n2}$; …; and M_{1m}, $M_{2m} \ldots M_{nm}$ which correspond to N regions (23) and (24) made of N channel FETs or the like is connected to each of the lines L_1 to L_m. The term used herein "n" refers to the number of horizontal scan lines. Each of the other ends (N region (24)) of the switching elements M_{11} to M_{nm} is connected to a target terminal (14) through liquid crystal cells C_{11}, $C_{12} \ldots C_{nm}$ including the pixel electrode (30) to the target electrode (37).

Further, an n-stage shift register (15) is provided and clock signals Φ_{1V} and Φ_{2V} at horizontal frequency are provided to the shift register (15). Driving pulse signals ϕ_{V1}, $\phi_{V2} \ldots \phi_{Vn}$ which are progressively scanned by the clock signals Φ_{1V} and Φ_{2V} from each of output terminals of the shift register (15) are provided to control terminals equivalent to the conductive layer (27) of each X-axis directed line (M_{11} to M_{2m}), (M_{21} to M_{2m})… (M_{n1} to M_{nm}) in the switching elements M_{11} to M_{nm}.

Therefore, in the circuit, the clock signals Φ_{1H}, Φ_{2H}, Φ_{1V}, and Φ_{2V} are provided to the ring counter (12) and the shift registers (13) and (15) as shown in FIGS. 4A and 4B. ϕ_{H1} to ϕ_{Hn} are outputted from the shift register (13) in each pixel period as shown in FIG. 4C and ϕ_{V1} to ϕ_{Vn} are outputted from the shift register (15) in each horizontal period as shown in FIG. 4D. Further, a signal shown in FIG. 4E is provided to input terminals (1R) to (1B) respectively.

When ϕ_{V1} and ϕ_{H1} are outputted, the switching elements M_1 and M_{11} to M_{1m} are tuned ON and a current path of an input terminal (1) → M_1 → L_1 → M_{11} → C_{11} → the target terminal (14) is formed to provide to a liquid crystal cell C_{11} potential difference

between the signal provided to input terminals (1R) to (1B) and the target terminal (14). Consequently, in capacitive component of the cell C_{11}, charge equivalent to potential difference of a signal for the first pixel is sampled and held. Light transmittance of the liquid crystal varies according to the charge. The same thing is carried out sequentially in cells C_{12} to C_{nm}, moreover, an amount of the charge of each cell C_{11} to C_{nm} is rewritten once the signal for the next field is provided.

As described above, light transmittance of the liquid crystal cells C_{11} to C_{nm} varies according to a picture signal for each pixel sequentially and repeatedly to display television images.

Since the image signal is dot-sequential primary color signals in each pixel, color images can be displayed by synchronizing the colors of color filters (32R) to (32B) and the primary color signals.

Thus color images are displayed. According to the device, deterioration of color reproducibility due to that unselected colors are appeared does not occur, since the liquid crystal formed over the color filters becomes black to shut out unselected pixels. Further, problems such as a color mixture, deterioration of light utilization efficiency, and degradation of resolution do not arise because the liquid crystal and the color filters are extremely close to each other, and so a gap between them is not caused.

FIG. 5 shows another example of a circuit. In this example, each line of L_1 to L_3 is connected to each color filter (32R) to (32B) sequentially. Lines L_4 to L_m are also connected to the color filters (32R) to (32B) in the same manner. Input terminals (1R) to (1B) are respectively connected to the each connecting point. This example will provide the same effects as the foregoing circuit provided with a dot-sequential signal.

In the foregoing examples, an effective voltage supplied to the liquid crystal (35) is decreased due to that the color filters (32R) to (32B) are provided. In other words, when the liquid crystal and the color filters are series connected, the relation between the effective voltage V′ and an input voltage V is described as follows:

$$V' = (C_{LC}/C_{LC}+C_F)\ V$$

where C_{LC} represents capacitance of the liquid crystal, and C_F represents capacitance of the color filters. The voltage has to be amplified to supply by the decreased effective

voltage when the signal is applied.

In the foregoing examples, an organic filter can be formed by performing the same process as the circuit, with a mask or the like, or by bonding as the color filters (32R) to (32B). Alternatively, an interference filter can be formed by processing the surface of the pixel electrode (30) directly. When using the interference filter, the decreasing of the voltage described above is not required to be considered. Further, the surface of the pixel electrode can be either of a white scattering plane or a mirror plane.

In the foregoing examples, a color display can be realized by a reflective liquid display device. A silicon substrate can be used in the case of the reflective liquid crystal display device. Consequently, reliability as a device becomes quite improved. Further, leak of the light into the device can be prevented, and so carrier generation due to light becomes vanishingly decreased.

In the foregoing examples, an image is displayed using three colors of red, green, and blue. However, a hue can be also displayed using only two colors of red and green or red and blue. Alternatively, any four or more colors can be used to display the hue more exactly.

A bottom electrode can be applied to devices of multiplex or passive matrix driving by a voltage averaging method or the like, instead of a TFT array such as silicon MOS, silicon on sapphire, amorphous silicon, and poly silicon, or an active matrix array such as an organic semiconductor.

Effects of the Device

According to the present invention, a high-quality color display with a simple structure can be realized.

Brief Description of the Drawings

FIG. 1 is an explanatory view of a conventional device, FIG. 2 is a structural view of one example of the present device, and FIGs. 3 to 5 are explanatory views of the FIG. 2.

Reference numeral (30) denotes pixel electrode; (32R), (32G), and (32B), color filters; (35), liquid crystal; (37), target electrode.

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